

EFFECT OF PHOSPHORUS FERTILIZER ON SOME SOIL CHEMICAL PROPERTIES AND NITROGEN FIXATION OF LEGUMES AT BAUCHI

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ABSTRACT

Research was conducted during the 2004, 2005 and 2006 cropping seasons to study the effect of phosphorus fertilizer on some soil chemical properties and nitrogen fixation of legumes at Bauchi. Composite soil samples were collected from sites before planting and after harvesting at the depths of 0-15 and 15-30cm. The treatment consisted of legumes namely; cowpea local variety (Yar Sokoto), groundnuts (Ex-Dakar) and soybean (TGX1448-2E) and four levels of phosphorus fertilizer (0, 13.2, 26.4 and 39.6kgP/ha). The experiment was laid out in a randomized complete block design (RCBD) with three replications. The result shows that soil pH., organic carbon, total nitrogen and available phosphorus increased in the soil samples collected after harvesting as compared to the soils sample before planting across the depths. Phosphorus fertilizer application significantly ($P=0.05$) increase nitrogen fixation up to 26.4kgP/ha, but decline significantly ($P=0.05$) at higher levels of 39.6kgP/ha in the cropping seasons. Legumes differ significantly ($P=0.05$) in their ability to fixed nitrogen, with soybean fixing the highest amount of nitrogen in the cropping seasons. Interaction between phosphorus fertilizer application and legumes show that in 2004 cropping seasons the application of 13.2kgP/ha gave significantly ($P=0.05$) the same amount of nitrogen fixed irrespective of the legumes, but in 2005 and 2006 cropping seasons, the interaction shows that at 0kgP/ha phosphorus levels of the amount of nitrogen fixed by the legumes was significantly the same. It is concluded that the application of phosphorus fertilizer did not only increase the nutrient status of the soil but enhance the nitrogen fixation ability of the legumes for a sustainable legume production and soil fertility management at Bauchi

KEYWORDS: Phosphorus fertilizer, chemical properties, nitrogen fixation, legumes and Bauchi

INTRODUCTION

Phosphorus is one of the most important soil nutrients next to nitrogen require by plants in large amounts. It is an important element in providing cellular energy for biochemical synthesis in plants (Hoffland *et al.*, 1989). With decline in soil fertility and increasing low soil pH in fragile soils of tropical savanna, phosphorus is gradually becoming unavailable to plants (Uyovbisere *et al.*, 2000), usually due to fixation by the oxides of Fe and Al and their hydroxides (Moyin-Jesu, 2008). Legumes are phosphorus loving plants; they require phosphorus for growth and seed development, and most especially in nitrogen fixation which is an energy driving process. Legumes can fix between 11-120kgN/ha (Sanginga, *et al.*, 2000), this is not achievable in the tropics because of low soil fertility and poor farming practices. In crop rotation, legumes are known to contribute significantly to the yields of subsequent crops like cereals and tubers (Nottidge *et al.*, 2008), this has been attributed to the amount of nitrogen and other nutrients returned into the soil by the legumes. Careful application of phosphorus fertilizer to legumes must be geared towards enhancing not only their growth and yield, but also nitrogen fixation. In Nigeria, legumes do not receive any form of mineral P-fertilizer, they therefore rely entirely on the natural available soil phosphorus and other nutrients for N-fixation and growth and this has resulted in lower yield and low N-fixation by these legumes. The present study was carried out to determine the effect of phosphorus fertilizer on the N-nitrogen fixing efficiency of grain legumes and its effect on some soil chemical properties.

MATERIALS AND METHODS

Experiment Site

Field experiments were conducted at the Abubakar Tafawa Balewa University, Bauchi Research and Training Farm during the raining seasons of 2004, 2005 and 2006 cropping seasons. Bauchi State is located between latitude 10°74'N and 9°47'E and situated at 690.3m above sea level in the northern guinea savanna zone of

Nigeria. The experimental sites had been under maize cultivation, and the soils are generally classified as altisols.

Treatment and Experiment Design

The treatments consisted of three legumes cowpea (Yar- Sokoto), groundnuts (Ex-Dakar) and soybean (TGX1448-2E) and four levels of phosphorus fertilizer (0, 13.2, 26.4 and 39.6kgP/ha), applied as single super phosphate. The twelve treatment combinations were laid out in a randomized complete block design with three replications, with plot size each of 6m².

Land Preparations

Land preparations included ploughing and harrow using tractor driven equipments. Phosphorus fertilizer was applied prior to sowing according to the treatments, and the legumes were planted. The plots were kept weed free, throughout the growing period by manual weeding.

Nitrogen fixation was estimated as described by Danso *et al.*, (1989), Hardarson and Danso, (1993) Khan *et al.*, (2000) and Sanginga, (2003).

Soil Sample Analysis

Composite soil samples were collected from experimental sites before and after harvesting at the depths of 0-15cm and 15-30cm. The samples were oven dried ground and sieved through a 2mm sieve and analysed for some chemical properties. Soil pH was measured with a glass-electrode pH meter in soil-water ratio of 1:1 (H₂O) while organic carbon was determined by the Walkley and Black, (1934) method. Total nitrogen was determined by the microkjeldalh method and extraction of available phosphorus was done using Bray 1 solution (Bray and Kurtz, 1945). The phosphorus in the extract was assayed electrochemically by ammonium molybdate blue using 1N neutral ammonium acetate solution. (Murphy and Riley, 1962)

Data Analysis

The data collected was statistically analysed using MINITAB statistical package for the analysis of variance (ANOVA). Means were compared using the least significant difference (LSD) at 5% level of probability when F-ratio was significant.

RESULTS

The chemical properties of the soil used for the experiments in 2004, 2005 and 2006 are shown in Table 1. The soil pH were moderately to slightly acidic which ranges from 5.65-6.83 across the depths. Soil pH decreased with increase in depths in the entire soil samples collected after harvesting, but before planting the soil pH was inconsistent with depth. Organic carbon was generally low, which ranges between 0.49-0.96 kg/ha across depth. However, all the soil samples collected after harvesting showed increase in organic carbon content which decreases with increase in depth. Total nitrogen and available phosphorus content also show a similar trend. Total nitrogen ranges between 0.45 – 0.79g/ha across the depth, and available phosphorus ranges between 5.77 – 9.38g/ha across depths. Soil samples collected after harvesting shows an increase in total nitrogen across the depth. Available phosphorus which decreases with increase in depth except for the value of available phosphorus obtained after harvesting in 2004, there was increase in phosphorus between the samples. However, all the chemical properties show great variations in their concentration across the depths before planting in the cropping seasons.

The result in table 2 shows estimated N-fixed by the legumes in 2004, 2005 and 2006 cropping seasons. There was a significant (P=0.05) difference in the amount of N-fixed by the different legumes in the 3years of the research. Soybeans fixed significantly higher nitrogen than cowpea and groundnuts in 2004 while in 2005 and 2006, soybean and cowpea fixed significantly higher nitrogen than groundnuts.

The application of phosphorus also significantly (P=0.05) affected the amount of N fixed by the legumes within the period of the research. The application of 26.4kgP/ha significantly gave highest amount of N-fixed, in all the cropping seasons. This was followed by the application of 13.2kgP/ha which was significantly higher than the control and the 39.6kgP/ha application.

Table 3a shows the interaction between phosphorus fertilizer level and legumes in 2004 cropping season. Application of phosphorus at 13.2kgP/ha to the legumes significantly (P=0.05) fixed equal amount of nitrogen

irrespective of the legume species, but as the levels increases the fixation estimates increase significantly ($P=0.05$) with increase levels of phosphorus to 26.4kgP/ha and declines significantly at higher levels of application 39.6kgP/ha. However, that was not the case in tables 3b and 3c which shows the interaction between levels of phosphorus fertilizer and legumes in 2005 and 2006 cropping seasons. The result shows that at 0kgP/ha level phosphorus, the legumes fixed significantly ($P=0.05$) the same amount of nitrogen, as the level of phosphorus fertilizer increase there was a significantly ($P=0.05$) variation in the amount of N-fixation between the legumes, with the highest N fixed values obtained at 26.4kgP/ha which decreases significantly ($P=0.05$) at higher levels of 39.6kgP/ha.

DISCUSSION

The results of the study confirm that the changes in the nutrient status of the soil were influenced by the application of phosphorus fertilizer resulting in an increase in soil fertility. The low levels of total nitrogen and available phosphorus on the soil samples before planting is as a result of low organic carbon in the soil, which has resulted to low soil pH. At lower pH Fe and Al oxides and their hydroxides react with the available phosphorus and form complexes that are insoluble in soil solution (Moyin-Jesu, 2008), thereby fixing the phosphorus in the soil and rendering it unavailable to plants. The low organic carbon could be attributed to high mineralization of organic matter of the soil. The higher values of the soil chemical properties obtained in the soil samples collected after harvesting could be due to the fact that the dropping of the crop residues especially the leaves at maturity could have added organic matter to the soil which has lead to the tremendous increase in organic carbon especially on the soil surface, total nitrogen and available phosphorus and increase soil pH (Adeniyi and Ojeniyi, 2005 and Adeniyi, 2008). It can also be stated that the residual effect of phosphorus fertilizer application might have contributed to the higher values of available phosphorus in the soil because of immobility of phosphorus in the soil

Phosphorus application significantly ($P=0.05$) increase nitrogen fixation of the legumes at 26.4 kgP/ha even though legumes response differently to the phosphorus application in their ability to fix atmospheric nitrogen (Singleton *et al.*, 1985), but it is evident that nitrogen fixation increases with increase in phosphorus application up to 26.4 kgP/ha, the decline in the nitrogen fixation at higher levels of phosphorus could be attributed to phosphorus toxicity. The legumes varied significantly in their ability to fix nitrogen with soybean fixing significantly higher nitrogen ($P=0.05$) than the other legumes. This can be attributed to the promiscuous behavior of soybean, its ability to be nodulated by various species of rhizobia (Sanginga, *et al.*, 2000), which enables it to fix nitrogen in association with any given soil rhizobia condition when compared to the other legumes that are host specific in their fixation abilities.

Interaction between the phosphorus fertilizer and legumes shows that legume response to phosphorus application varied significantly ($P=0.05$). Application of 13.2kgP/ha in 2004 cropping season and 0kgP/ha phosphorus level in 2005 and 2006 made the legumes to fix significantly ($P=0.05$) the same amount of nitrogen. This is attributed to the low levels of phosphorus in the soil samples as result of low pH in 2004 cropping seasons, resulting in low phosphorus, which was unable to enhance N-fixation of the legumes.

In conclusion, this study confirms that legumes respond adequately to phosphorus fertilizer application and results in increase in nitrogen fixation as well as enhancing the chemical properties of the soil for a sustainable legume production and soil fertility management at Bauchi.

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Table 1: Some chemical properties of the soils before and after the experiment at the experimental sites in 2004, 2005 and 2006 cropping seasons

cropping seasons	period of sampling	depth of sampling (cm)	soil pH (H ₂ O)	1:1 organic carbon g/kg	total nitrogen g/kg	available phosphorus (mg/kg)
2004	Before planting	0-15	5.65	0.51	0.56	5.77
		15-30	5.74	0.49	0.45	5.88
	After harvesting	0-15	6.79	0.72	0.68	6.71
		15-30	6.21	0.55	0.52	8.33
2005	Before planting	0-15	3.04	0.62	0.61	6.03
		15-30	6.02	0.57	0.55	6.00
	After harvesting	0-15	6.76	0.96	0.78	9.38
		15-30	6.46	0.64	0.66	9.13
2006	Before planting	0-15	6.06	0.61	0.63	6.00
		15-30	6.17	0.59	0.60	6.02
	After harvesting	0-15	6.83	0.95	0.79	9.24
		15-30	6.44	0.64	0.67	8.97

Table 2: Effect of phosphorus fertilizer on nitrogen fixed of legumes in 2004, 2005 and 2006 cropping seasons at Bauchi

Treatment	Estimated nitrogen fixed (kgN/ha)		
	2004	2005	2006
Legumes			
Cowpea (Yar- sokoto)	21.94 ^b	29.50 ^a	29.84 ^a
Groundnut (Ex-Dakar)	20.06 ^b	25.20 ^b	26.57 ^b
Soybean (TGX1448-2E)	24.85 ^a	30.90 ^a	31.70 ^a
SE(±)	0.76	0.62	0.77
LSD (P=0.05)	2.65	2.17	2.68
Phosphorus (kgP/ha)			
0	13.74 ^c	17.63 ^c	19.06 ^c
13.2	23.06 ^b	30.05 ^b	30.27 ^b
26.4	35.88 ^a	46.50 ^a	47.23 ^a
39.6	16.45 ^c	19.96 ^c	20.93 ^c
SE(±)	0.88	0.72	0.89
LSD (P=0.05)	3.06	2.50	3.09

Means followed by the same letter(s) within a column are not significantly different (P=0.05)

Key:

SE = Standard error

LSD = least significant difference

Table 3a: Effect of interaction between phosphorus and legumes on nitrogen fixed in 2004 cropping seasons at Bauchi.

Treatment	Legumes		
	Cowpea	Groundnut	Soybean
Phosphorus (kgP/ha)			
0	13.00 ^e	11.29 ^e	16.92 ^d
13.2	23.46 ^c	22.01 ^c	23.72 ^c
26.4	37.49 ^a	32.41 ^b	37.75 ^a
39.6	13.81 ^e	14.53 ^{de}	21.00 ^c
SE(±)		1.53	
LSD (P=0.05)		3.06	

Means followed by the same letter(s) within a column are not significantly different (P=0.05)

Table 3b: Effect of interaction between phosphorus and legumes on nitrogen fixed in 2005 cropping seasons at Bauchi.

Treatment	Legumes		
	Cowpea	Groundnut	Soybean
Phosphorus (kgP/ha)			
0	18.04 ^{ef}	18.45 ^{ef}	19.40 ^{ef}
13.2	31.95 ^c	26.70 ^d	31.49 ^c
26.4	47.95 ^a	39.72 ^b	51.83 ^a
39.6	20.05 ^e	15.45 ^f	20.87 ^e
SE(±)		1.25	
LSD (P=0.05)		4.34	

Means followed by the same letter(s) within a column are not significantly different (P=0.05)

Table 3c: Effect of interaction between phosphorus and legumes on nitrogen fixed in 2006 cropping seasons at Bauchi.

Treatment	Legumes		
	Cowpea	Groundnut	Soybean
Phosphorus (kgP/ha)			
0	19.01 ^e	18.65 ^e	19.51 ^e
13.2	31.73 ^c	27.08 ^{cd}	32.01 ^c
26.4	48.88 ^a	40.60 ^b	52.20 ^a
39.6	19.76 ^e	19.95 ^e	23.07 ^{de}
SE(±)		1.54	
LSD (P=0.05)		5.36	

Means followed by the same letter(s) within a column are not significantly different (P=0.05)

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